The Construction of the ICRF2 and its impact on the Terrestrial Reference Frame

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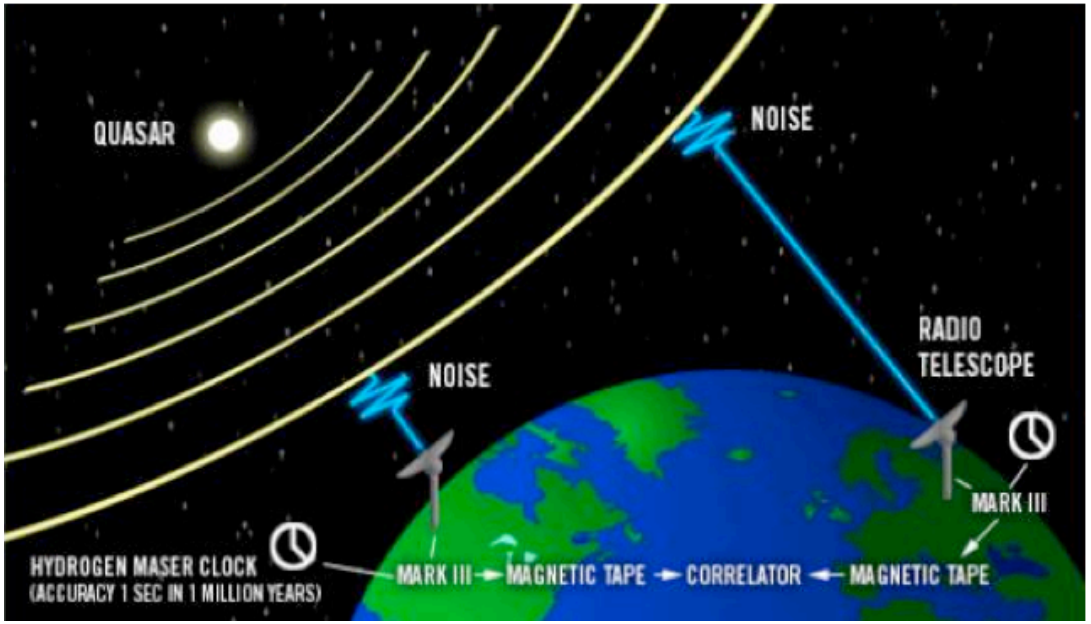
Introduction:

Very Long Baseline Interferometry (VLBI) gives the best realization of the International Celestial Reference Frame (ICRF)

- For imaging distant cosmic radio sources, spacecraft tracking, and for applications in astrometry.
- Measurements from distant sources (such as quasars) observed with a global network of antennas.
- Earth Orientation Parameters (EOP), station positions, radiosources coordinates.



The International Celestial Reference Frame ICRF2

Characteristics and comparison with the first realization of the ICRF

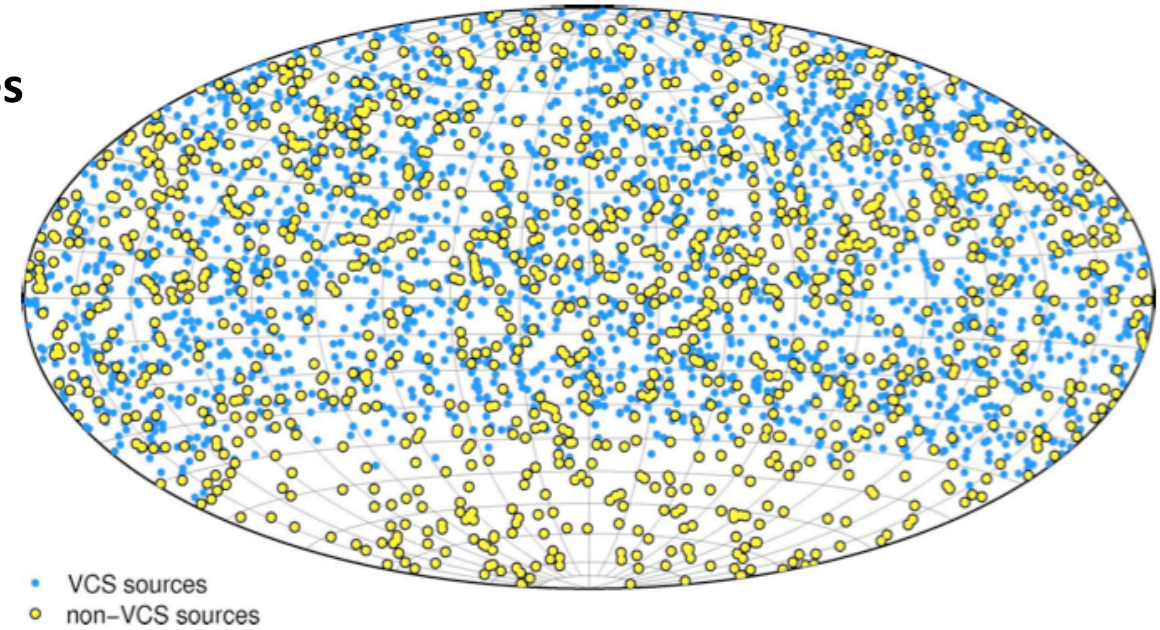
ICRF2 characteristics and comparison with the first realization of the ICRF

- ICRF2 was adopted by the IAU in 2009 and became official on January 1st, 2010;
  - ICRF adopted by the IAU in 1997 and official on January 1st, 1998.
- Positions of 3414 sources (1448 in multiple VLBI sessions and 1966 in single VLBI sessions).

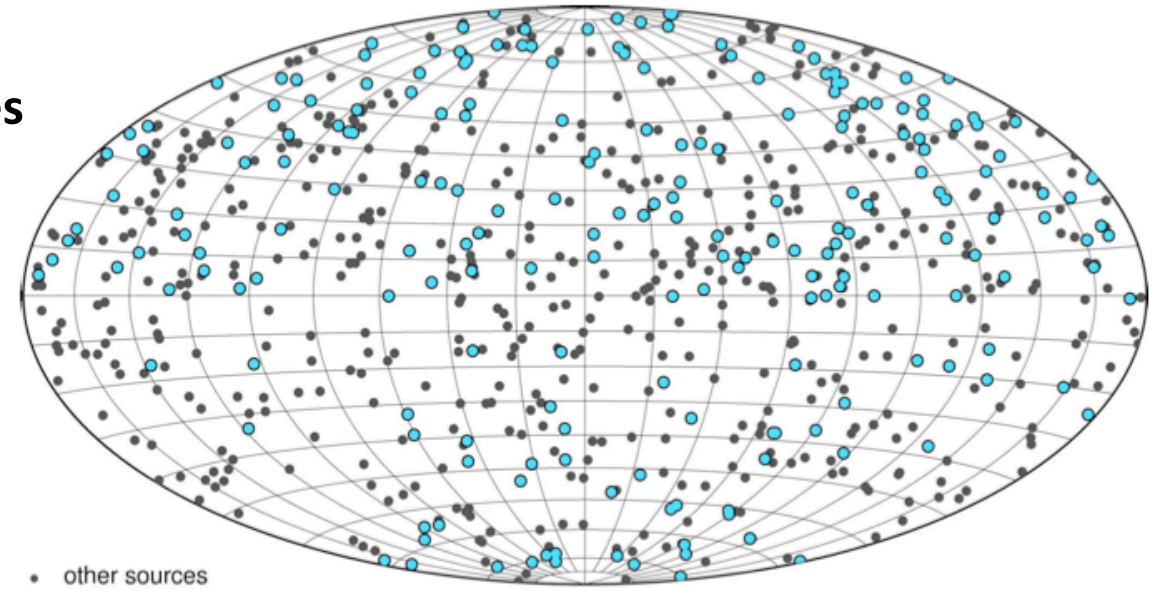
	ICRF	ICRF2
VLBI data	Aug. 79 – July 95	Aug. 79 – March 09
# VLBI Observations	~ 1.6 million	~ 6.6 million
# Defining sources	212	295
# Total sources	608	3414
Noise floor	~ 250 µas	~ 40 µas
Axis stability	~ 20 µas	~ 10 µas

ICRF2 characteristics and comparison

ICRF2 sources

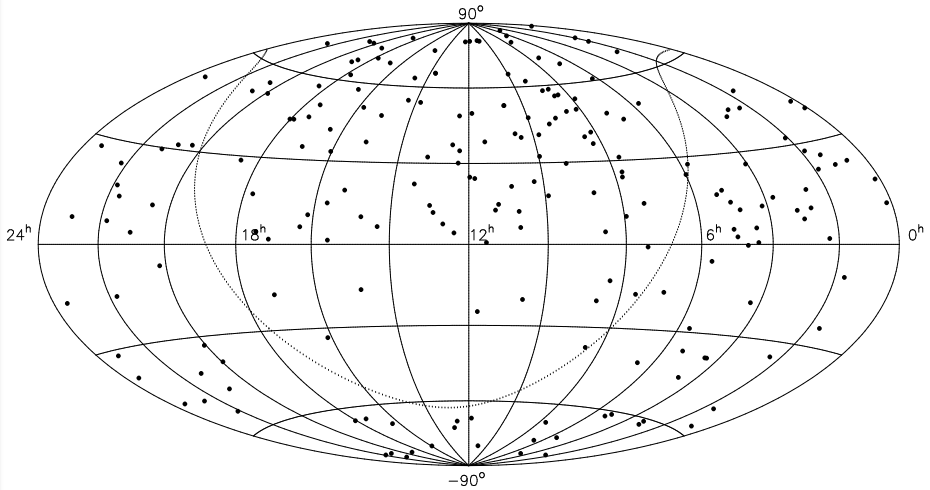


ICRF1 sources

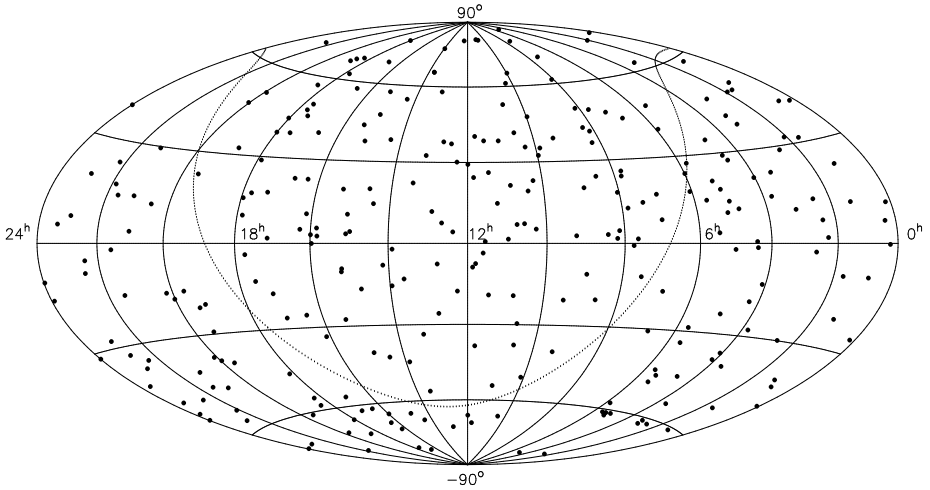


ICRF2 defining sources

- ICRF2 defining sources characteristics:
  - Even distribution over the sky (study in four parts of the sky with a partition function of the declination);
  - Quality of the observations (positional stability of RA and DEC via WRMS, χ2 and formal errors);
  - Compactness of the source (source structure index);
  - Only 97 of the original 212 ICRF defining sources.



212 ICRF defining sources



295 ICRF2 defining sources

Impact of the ICRF change on TRF, CRF and EOP

Switch from the first realization of the ICRF to ICRF2

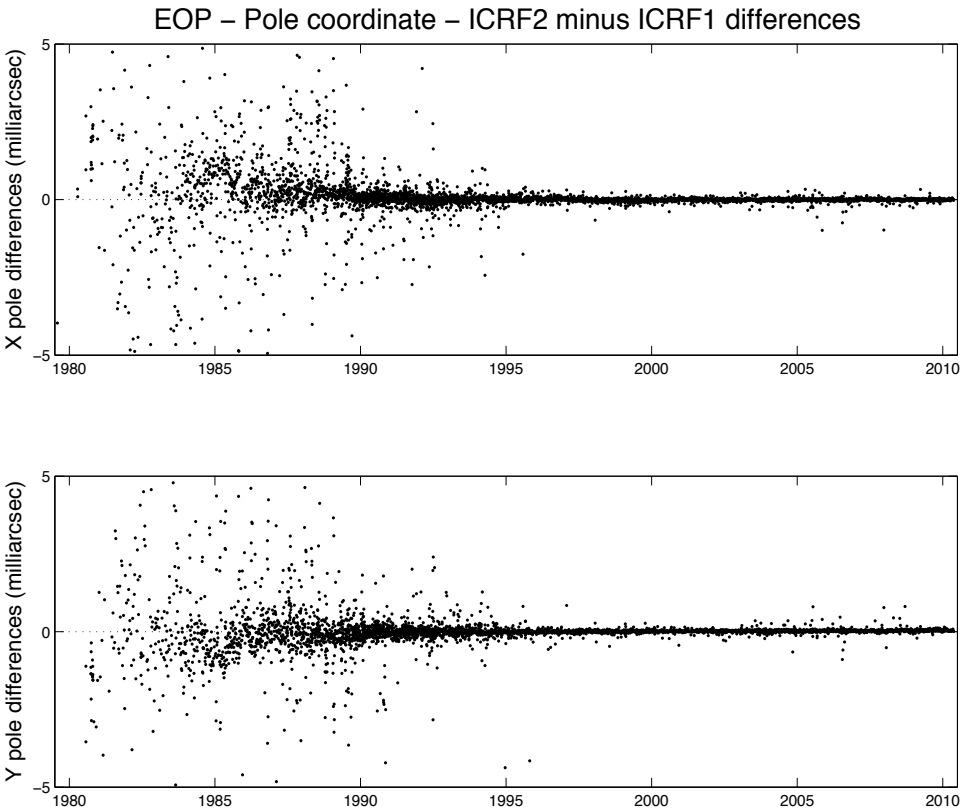
Impact on the Terrestrial Reference Frame

- Solutions compared:
  - ICRF2-based solution (gsf2010a):
    - *Calc/Solve* software;
    - A priori: ICRF2 catalog positions for the defining sources;
    - Solve for global source positions, but constrain on the adjustments of the defining sources such that there is no net rotation (NNR) of the set of defining sources;
    - Coordinates of 39 special handling sources solved as arc parameters;
    - Solve for daily EOP's and global site positions and velocities.
  - ICRF1-based solution:
    - Same setup and data;
    - ICRF1 defining sources and their ICRF1 positions for a NNR constraint;
    - The 39 unstable sources were not given special handling (global solution).
- Determination of the Helmert parameters of the two obtained sets of site positions and velocities.

Tx (mm)	Ty (mm)	Tz (mm)	Rx (µas)	Ry (µas)	Rz (µas)	Scale (ppb)
-0.08 ±0.17	-0.25 ±0.18	+0.26 ±0.16	+17.4 ±7.1	+2.9 ±6.8	-0.7 ±4.9	0.007 ±0.022

Impact on the EOP

- Daily Earth Orientation Parameters compared between the two solutions.
- Small systematic EOP differences about the same size as differences between quarterly solutions.



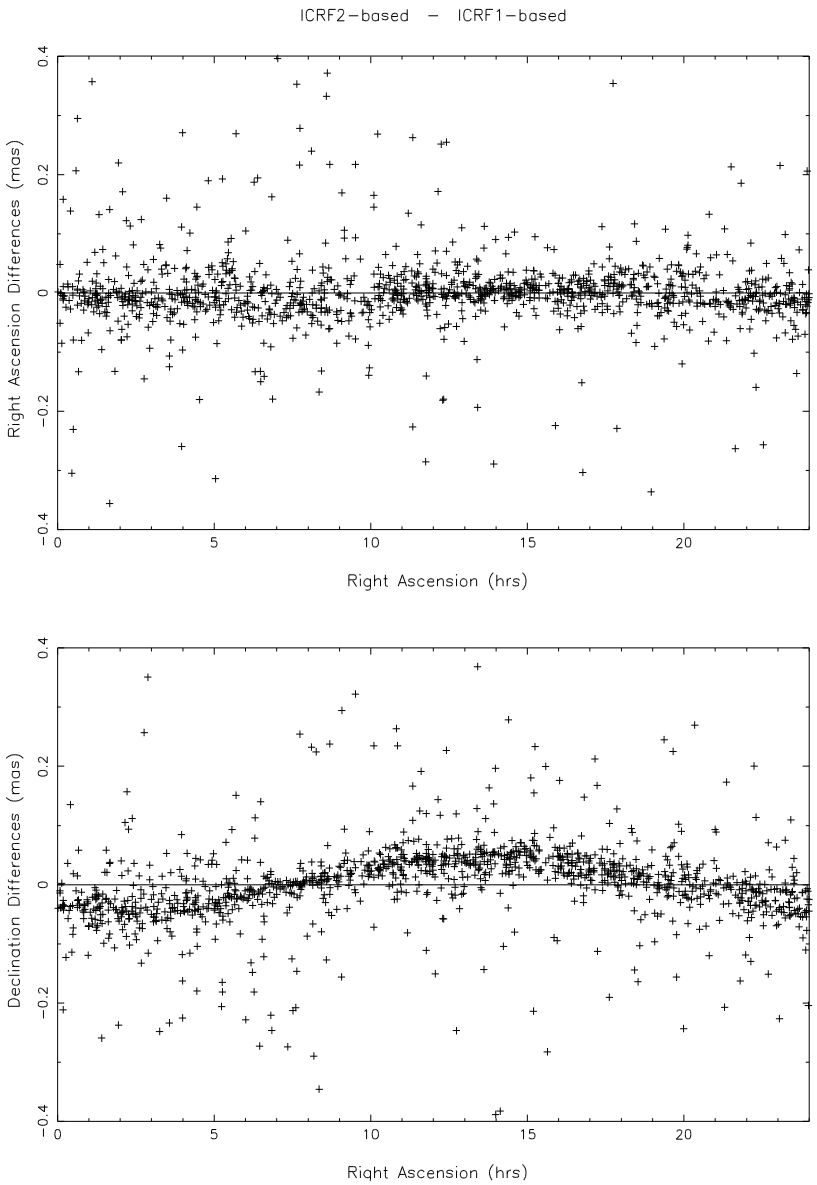
	Shift	Drift (yr^{-1})	WRMS	R1/R4 uncert.
p_x(μas)	11.1 ±0.8	-1.8 ±0.2	47.5	~40-150
p_y(μas)	-4.0 ±0.7	3.3 ±0.1	40.5	~40-150
dUT1(μs)	-0.5 ±0.1	0.07 ±0.10	2.8	~1.5-4.0
dX(μas)	37.6 ±0.8	-0.4 ±0.1	47.3	~30-100
dY(μas)	20.8 ±0.8	0.1 ±0.1	45.5	~30-100
$\dot{p}_x$(μas/d)	2.3 ±2.2	0.2 ±0.4	125.0	~120-300
$\dot{p}_y$(μas/d)	-2.2 ±2.1	0.0 ±0.4	122.0	~120-300
$\dot{dUT1}$(μs/d)	0.05 ±0.09	-0.01 ±0.02	5.2	~4-10

EOP differences, ICRF2-based vs ICRF-based

Impact on the Celestial Reference Frame

- Rotation between the two solutions, using 1167 common sources:

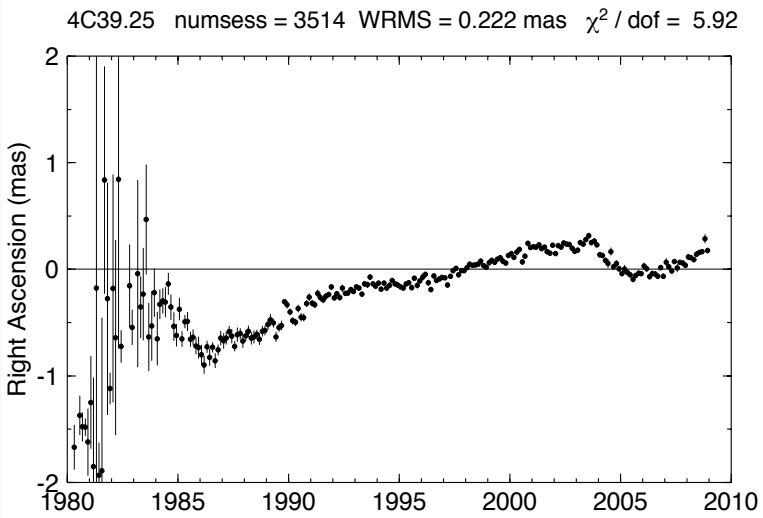
A1(μas)	A2(μas)	A3(μas)
+17.8±0.5	-38.8±0.5	3.6±0.4

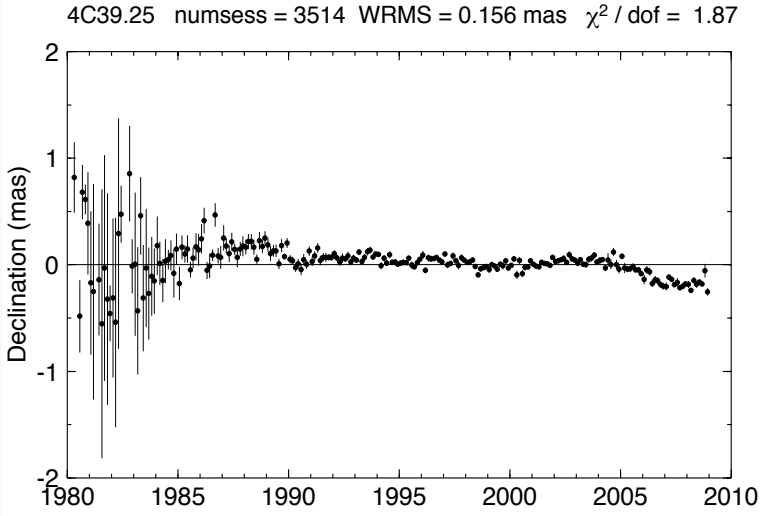


Perspectives and improvements already done on the ICRF2

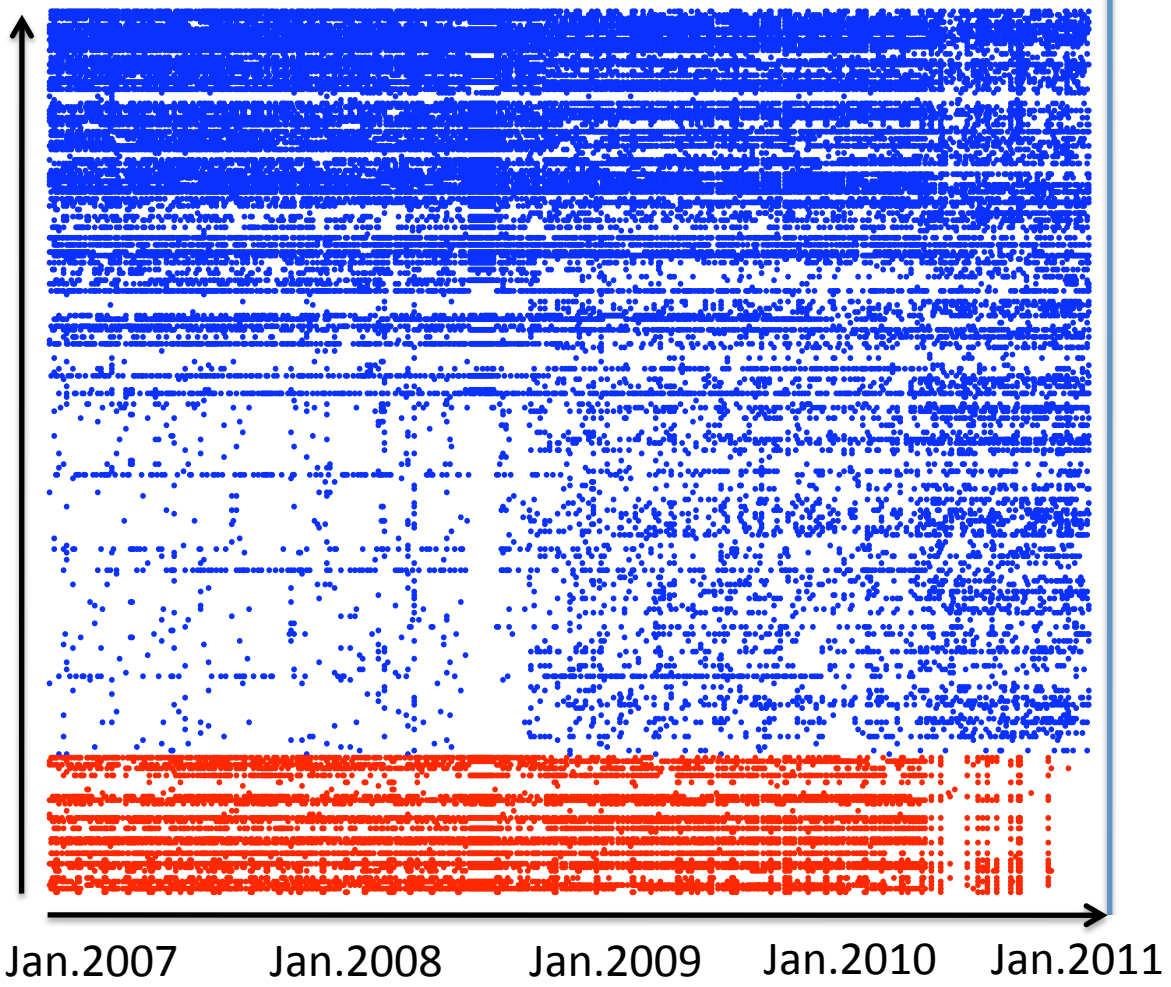
The case of the Special Handling Sources

The 39 "Special Handling" sources





Observation history of the 250 most observed VLBI sources from Jan. 2007 to April 2011



Special handling sources

211 most observed sources

Conclusions

- Progress on the ICRF:
  - The ICRF2 was build more automatically;
  - It contains much more data than the first ICRF;
  - The set of observed sources significantly increased;
  - The defining sources have more uniform sky coverage;
  - The WRMS and the noise of ICRF2 are significantly reduced in comparison with ICRF1;
  - The switch from ICRF1 to ICRF2 does not have a significant impact on the ICRF and the EOP.
- Small rotation of the CRF.
- But weakness: The network of stations is still poor in the South Hemisphere.
- Perspectives:
  - VLBI2010;
  - Study of sources positions in more details to search for structure and noise (Special Handling sources).

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  "Effects of ICRF2 on the TRF, CRF, and EOP"

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